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Forum article

Statistical Language Backs Conservatism in Climate-Change Assessments

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Key-words: climate change; communication; Intergovernmental Panel on Climate Change; terminology; uncertainty.

Abstract

The scientific evidence for anthropogenic climate change is empirically settled, but communicating it to non-scientific audiences remains challenging. To be explicit about the state of knowledge on climate science, the Intergovernmental Panel on Climate Change (IPCC) has adopted a vocabulary that ranks climate findings through certainty-calibrated qualifiers of *confidence* and *likelihood*. We here quantified the occurrence of knowns and unknowns about 'The Physical Science Basis' of the IPCC's Fifth Assessment Report by counting the frequency of calibrated qualifiers. We found that the tone of the IPCC's probabilistic language is remarkably conservative (mean *confidence=medium, likelihood*=66-100%), and emanates from the IPCC recommendations themselves, complexity of climate research, and exposure to politically-motivated debates. Leveraging communication of uncertainty with overwhelming scientific consensus about anthropogenic climate change should be one element of a wider reform, whereby the creation of an IPCC Outreach Working Group could enhance the transmission of climate science to the Panel's audiences.

Communicating scientific and statistical uncertainty to non-academic audiences, including

policymakers, is one of the most important challenges of modern science. This is particularly

true for climate science where the risks posed by anthropogenic climate disruption have become

a strategic topic among rivalling political ideologies (McCright and Dunlap 2011), and represent

considerable losses in actual and future economic production (Burke et al. 2015), as well as an

unprecedented threat to human health (McMichael 2013), and to biodiversity and the multiple

ecosystem services it provides to human societies (Scheffers et al. 2016). Despite the climate-

change community leading the development of a quantitative language for uncertainty (Morgan

and Mellon 2011), communication experts question whether the conveyance of uncertainty to the

public might in fact promote political inaction for dealing with the environmental and social

impacts of a changing climate (Lewandowsky et al. 2015a). In this *Forum* article, we analyze the

major linguistic effort made by the Intergovernmental Panel on Climate Change (IPCC) to

communicate the (un)certainty of climate science to its target audiences, and we quantify the

occurrence of knowns and unknowns present in IPCC reports by counting the frequency of

statements reported to a given range of uncertainty. We then explain why transparency about

scientific uncertainty renders the IPCC's reporting conservative, and finally we identify

challenges and propose future directions that could bolster the IPCC's communication strategy

and the public transmission of climate science as a whole. Our scope is to provide a constructive

overview of the IPCC's probabilistic language explicitly free of statistical analyses.

Intergovernmental Panel on Climate Change

Effective communication has been a major area of elaboration and concern for scientists in the

IPCC, who are consistently challenged with adhering to scientific rigour while delivering clear

4

and unambiguous messaging (Lynn 2018). Established in 1988 by the United Nations' World

Meteorological Organization and Environmental Program, and with a current membership of 195

countries, the principal duty of this Panel rests on the review of the climate-related primary and

secondary literature by three Working Groups (known as WGI, II, and III), and on the evolving

development of methodologies by the 'Task Force on National Greenhouse Gas Inventories' for

calculating greenhouse-gas emissions and removals. The IPCC's overarching goal through their

Working Groups is to assess the physical sciences of climate change (WGI), its potential socio-

economic consequences in terms of impacts, adaptation and vulnerability (WGII), and the

associated mitigation options (WGIII). Their outputs are published in a series of periodical

reports. To date there have been five Assessment Reports, published in 1990, 1995, 2001, 2007

and 2013 (Jones 2013).

The (latest) Fifth Assessment Report is a compendium of four publications: an overall

'Synthesis Report' and one report from every Working Group (full content is listed by sections

in table S1). The 'Synthesis Report' subsumes the working-group outcomes in a technical

summary preceded by a 'Summary for Policymakers' (IPCC 2014d). The reports of the Working

Groups each consist of their own summary for policymakers and technical summary, in-depth

chapters, and supplements (IPCC 2013a: WGI, 2014a, b: WGII, 2014c: WGIII) — all fully

available from the IPCC's website (www.ipcc.ch). The elaboration of the technical summaries

and in-depth chapters is done by 'contributing authors' who provide the raw data (text, data,

graphs, tables), 'lead authors' who integrate and synthesize the input of contributing authors and

deal with comments from a selected group of 'expert reviewers', and 'coordinating lead authors'

who oversee completeness, coherence and style consistency (InterAcademy Council 2010). At

least two 'review editors' observe the whole assessment process for each in-depth chapter

(InterAcademy Council 2010). Synthesis Reports and Summaries for Policymakers follow a similar review process with additional participation of government representatives (Lynn 2018, see below).

Probabilistic language tailored to expected audiences

The IPCC reports are meant to inform a primary target audience of national governments, policymaking stakeholders, and intergovernmental actors across the United Nations (table 1), and represent the cornerstone of the United Nations Framework Convention on Climate Change as in the 2015 Paris Agreement. This role is essential because, in the current Information Age, it is striking that the primary literature of climate-change research has minimal coverage in policy (Bornmann et al. 2016). The IPCC fills the gap by acting as the principal mediator between the scientific community and governments in a global context, and so fuels the political response to anthropogenic climate disruption, with IPCC reports being policy-relevant but not policy-prescriptive (InterAcademy Council 2010).

Nonetheless, the IPCC acknowledges that many other sectors (business, educators, the media, observer organizations, the scientific community, and the public in general; table 1) are interested in its work and published reports, and might require context- and country-specific outreach (IPCC 2016a). Despite intending to engage such a global, broad and diverse audience, the style of IPCC reports unfortunately remains technical (Schellnhuber 2008), hence compromising the conveyance of scientific uncertainties to a broad audience (Lewandowsky et al. 2015a), and overall making their readability challenging for non-scientific audiences (Barkemeyer et al. 2016, but see Mach et al. 2017). Because IPCC reports are increasingly voluminous (Jones 2013), when the Sixth Assessment Report (and three additional reports that

focus on 'global warming, 'land', and 'ocean and cryosphere') sees the public light by 2022 (Lynn 2018), communication challenges are bound to grow in sync with the number of bytes of climate information.

To hone the communication and understanding of climate-science uncertainty to their expected audiences, the IPCC has adopted what it refers to as a "calibrated language" to rank scientific uncertainty. This strategy firmly aligns with the IPCC's communication strategy of "… providing clear and balanced information on climate change, including scientific uncertainties, without compromising accuracy" (IPCC 2016a). The expression "calibrated language" implies a common vocabulary and scale of judgment of the degree of certainty in findings (e.g., magnitude, pattern, prediction, projection, rate, trend) across IPCC Working Groups. Guidelines around how to construct calibrations by the IPCC's 'lead authors' have evolved through the Third (Moss 2011), Fourth (IPCC 2007) and Fifth (Mastrandrea et al. 2011a, Mastrandrea et al. 2011b) Assessment Reports, and currently consists of two sets of calibrated qualifiers: *confidence* and *likelihood*. *Confidence* is a qualitative composite of the strength of evidence (type, quality, amount, consistency) and the scientific agreement (proportion of different lines of evidence that support the same conclusion) available for a given finding (Mastrandrea et al. 2011a). By contrast, *likelihood* "… is used to express a probabilistic estimate of the occurrence of a single event or of an outcome" (Mastrandrea et al. 2011a). Figure 1 displays the five categories of *confidence* (from *very low* to *very high*) and ten categories of *likelihood* (from *exceptionally unlikely* to *virtually certain*) in the Fifth Assessment Report. IPCC Core Writing Team members have outlined a proposal to revise those qualifiers for future assessments (Mach et al. 2017), where *confidence* would turn to *scientific understanding* (five "unranked" categories

according to evidence and agreement: *limited*, *emerging*, *medium*, *divergent*, *robust*), while

likelihood categories would remain unchanged (figure 1).

Through the assessment process, IPCC's calibrations imply that the scale of scientific

evidence (based on published climate data and research) maps to a scale of assessment (based on

the collective judgement of IPCC lead authors); thus, calibrated qualifiers do not capture the

view of individual contributing authors or expert reviewers (Morgan 2014, see below). This

calibrated language undoubtedly reaffirms the sophisticated discourse of IPCC reports, but it

might ironically jeopardize the clarity with which they might resonate with non-scientific

audiences. Indeed, several studies have reported caveats in the communicative efficacy of the

IPCC's calibrations, which can be summarized as follows: (*i*) the media often uses the IPCC's

calibrated qualifiers without reference to their intended meanings (Collins and Nerlich 2016), (*ii*)

interpretation can be affected by the linguistic background of the audience (Budescu et al. 2014,

Harris et al. 2013), and (*iii*) general-public language is unfit to gauge the joint uncertainty of

related climate findings (Cooke 2015). An unexplored issue is that the IPCC's calibrations

delimit a continuous scale of how much we know and do not know about climate change — a

headline that receives considerable media coverage and public attention (e.g., Abraham 2013,

Barnard 2017, Frost 2014). We evaluate this tenet in the next section by quantifying the

frequency of calibrated qualifiers in the IPCC's Fifth Assessment Report.

Tone of the physical science of climate change

From the Fifth Assessment Report, we counted the number of *confidence* and *likelihood*

qualifiers in the WGI component as a case study (table S1). This Working Group sifts through

the literature of 'The Physical Science Basis' of how the climate system functions and changes

(IPCC 2013a), and has supported the overwhelming scientific consensus (Benestad et al. 2016, Cook et al. 2016, Oreskes 2004) that human activities have altered the Earth's climate on a historical timescale, and will continue to do as long as fossil fuels prevail as our main sources of energy (table 2).

Confidence and *likelihood* qualifiers can be easily tracked in the Fifth Assessment Report because they are italicized. We counted qualifiers separately in the 'Technical Summary' (Stocker et al. 2013), the 'Summary for Policy Makers' (IPCC 2013b), and the in-depth Chapters 2 to 14 each prefaced by a self-contained 'Executive Summary' (IPCC 2013a) — but excluded Chapter 1 because it is an introduction to concepts, definitions, climate-change indicators (and how they compare to the Fourth Assessment Report), scenarios, and the state of the art of climate science as used in the remaining chapters. We distinguished summaries from in-depth chapters in our analysis because the former flag the main outcomes of the latter, so both are distinct in terms of content and relevance (and potential audiences), and might be dominated by contrasting degrees of certainty. This is particularly the case for the 'Summary for Policymakers' because representatives of all IPCC-signatory governments carefully read line by line, make amendments, and finally approve the text in agreement with the Panel during a plenary session (Lynn 2018). For *likelihoods*, we pooled statements of identical probability; for instance, *very likely* and *very unlikely* indicate the same magnitude of uncertainty for a positive and negative statement, respectively (figures 1 & 2). To avoid the large displays (which we use hereafter to define boxes, figures and tables) in the in-depth Chapter 14 on future regional climate change biasing our counts (they accounted for 28% of total calibrations counted in all chapters; table S2), we show the frequency of qualifiers in the main text of the in-depth chapters in figure 2, and in displays in figure S1. We provide full methodological details in the Supplemental Material.

We counted 3191 calibrated qualifiers (1979 and 1212 *confidences* and *likelihoods*, respectively) in the IPCC WGI's 'The Physical Science Basis' — sample sizes shown in table S2. Throughout, we found that the proportions of the different qualifiers assigned to climate findings follow a nearly symmetric distribution (figure 2). In the Summary for Policymakers, 59% of the *confidence* qualifiers (*n* = 136) are *low* to *medium* (figure 2a), and 58% of the *likelihood* qualifiers (*n* = 120) are *likely* (66-100% probability) or *unlikely* (0-33% probability) (figure 2b). In figure 2a & 2b, horizontal grey lines are the means of qualifiers from lowest = 1 to highest = 5 (*confidence*) or 6 (*likelihood*) strength of evidence, indicating a mean (ranked) *confidence* of 3.3 ± 0.1 and *likelihood* of 3.5 ± 0.2 (± standard error; table S2). The 'Technical Summary' (figure 2c & d; *n* = 567 calibrated qualifiers), and the 'Executive Summaries' (figures 2e & f; *n* = 492) and main text of the in-depth chapters (figures 2g & h; *n* = 1136) match the trend of the 'Technical Summary' for both metrics, with mean *confidences* and *likelihoods* all from 3.1 to 3.5 (table S2), and medians fixed at 3 in all cases (table S2).

In all of those components, the proportion of the top categories of certainty (*very high*, *virtually certain/exceptionally unlikely*) never exceeded 8%. Therefore, when the IPCC's WGI synthesizes information about the physical phenomena, rates, and trends of climate change from in-depth chapters to their different summaries (and, potentially, audiences), the average certainty of the climate science assessed remains *medium* — probabilistically within 0-33% (*unlikely*) and 66-100% (*likely*) ranges. As shown in figure S1, these overall trends and conclusions persist when we counted *likelihood* qualifiers in the displays of the in-depth chapters, except that *high* confidence predominated in those displays due to climate findings documented in only three in-depth chapters, namely Chapters 2 ('Observations: Atmosphere and Surface'), 10

('Observations: Cryosphere') and 14 ('Climate Phenomena and their Relevance for Future

Regional Climate Change').

Uncertainty driving conservativeness

Overall, the predominance of qualifiers of low to intermediate certainty reported above reveals

that the tone of the probabilistic language of the IPCC's report on the physical science of climate

is remarkably conservative, and contrasts with the overwhelming scientific consensus about

anthropogenic climate change (Benestad et al. 2016, Cook et al. 2016, Oreskes 2004) that the

IPCC is endorsing (table 2). We argue below that such conservatism results from the combined

effect of three factors, namely the IPCC's guidelines themselves, research complexity, and

politically-motivated challenges.

IPCC's guidelines: The IPCC recommends that the calibrated assessment of climate findings

should be explicit about all sources and ranges of uncertainty, and often focuses on reference

probabilities of low magnitude. Table 3 shows four of such recommendations in the original

guidance notes for the Fifth Assessment Report's lead authors (Mastrandrea et al. 2011a), which

we describe below.

To the IPCC, reporting the tails of the distribution of low-probability adverse outcomes is

sensible because those tails can have major implications in climate-change science, impact,

adaptation, or mitigation (table 3). The most obvious case is where different ranges of the

magnitude of a climate-change metric receive specific calibrations (Mastrandrea et al. 2011b),

e.g., "… observed climate change, climate models and feedback analysis, as well as paleoclimate

evidence indicate that ECS [equilibrium climate sensitivity] is positive, *likely* in the range 1.5 °C

to 4.5 °C with *high confidence*, *extremely unlikely* less than 1 °C (*high confidence*) and *very unlikely* greater than 6 °C (*medium confidence*)" (Stocker et al. 2013).

This is somewhat akin to where the IPCC assesses the magnitude of a spatial or temporal metric such that certainty will normally decrease as estimates cover relatively poorly studied regions and longer periods (into the past or the future), often due to data deficiency and coverage, and alternative modelling approaches. For example, "… *confidence* in precipitation change averaged over global land areas is *low* prior to 1951 and *medium* afterwards because of insufficient data" and "… *low confidence* in basin-scale projections of changes in intensity and frequency of tropical cyclones … reflects the small number of studies exploring near-term tropical cyclone activity, the differences across published projections … and the large role for natural variability" (Stocker et al. 2013).

Likelihood categories in the IPCC's reports have "fuzzy" boundaries (table 3), and so can assign low to intermediate calibrations to findings that are highly probable (the opposite can also occur). This renders IPCC calibrations naturally conservative, e.g., the statement "… it is *likely* that human influence has affected the global water cycle since 1960" (Stocker et al. 2013) implies that anthropogenic forcing might be anywhere from 66% to 100% probable. The narrative of fuzzy boundaries is one that the non-scientific readers of IPCC reports might misunderstand because it is non-standard terminology (Cooke 2015) — instead, common reasoning is more bound to gauge the certainty of a *likely* event by the lower value (66%). Think of boarding an airplane that has a 66 to 100% chance of crashing; in this case, would the upper bound even matter to most people?

Importantly, the IPCC prompts its Working Groups not to rank the certainty of statements of fact in the IPCC calibration guidelines (table 3), and highlights this guideline with the same

12

sentence in the introductory section of the WGI's 'Summary for Policymakers' (IPCC 2013b, p. 4) and the 'Technical Summary' (Stocker et al. 2013, p. 35): "… where appropriate, findings are also formulated as statements of fact without using uncertainty qualifiers". These *facts* are sometimes (twice in the Technical Summary, ten times in the in-depth chapters) denoted by the term 'certain' subject to no qualifier or italicization , e.g., "… it is certain that global mean [land] surface temperature has increased since the late 19th century" (IPCC 2013b).

Climate complexity: Consensus in the scientific community regarding whether humans are altering the climate (Cook et al. 2016) is not proportional to, and should not be confused with, consensus in IPCC reports as expressed through calibrated qualifiers. The latter is applied to the multiple processes operating in the climate system, in which anthropogenic forcing is one of many other mechanisms at work. Along those lines, IPCC reports assess many different data and publications on complex, dynamic, and interacting systems (atmosphere, climate, ecosystems, oceans, human societies). Those systems are imperfectly understood with respect to their individual and interacting forcings, and keep shifting as climate-change progresses and novel feedbacks emerge, as much as the technology and methods to measure climate change are imperfect, evolving and improving. Uncertainty is thus an explicit property (not a weakness) of climate-change research and of IPCC reports and, for that matter, inherent to any field of research. In that respect, the review scope of the IPCC implies assessing single phenomena under multiple, plausible explanations that can further slant the number of calibrations towards uncertainty. We illustrate this aspect with three examples in the remainder of this section.

The IPCC must account for the fact that in the analysis of climate data, the uncertainty of observed effects will be commonly overshadowed by the uncertainty of their potential causes.

One thing is what we see and measure, another is which mechanism might trigger it. There is often one effect and several alternative or complementary explanations, and this unbalance can act as a multiplier of weak- *versus* strong-certainty qualifiers. For instance, the 'Summary for Policymakers' states as a fact that "… total radiative forcing is positive, and has led to an uptake of energy by the climate system [since the Industrial Revolution]", but the *confidence* of the contribution of different atmospheric drivers to that forcing varies through *low* (aerosol-mediated cloud adjustment), *medium* (albedo driven by land use, carbon monoxide, non-methane volatile organic compounds, NO_x, solar irradiance), *high* (CH_4, halocarbons) and *very high* (CO_2, N_2O) (IPCC 2013b). This statement deals with one effect, while four drivers score *high confidence* and six get *low* to *medium confidence*, and the range of those uncertainties is even stronger in expert elicitation (Morgan et al. 2006).

Additionally, when the IPCC assesses climate change into the future (or the past), it applies mathematical frameworks and assumptions of varying complexity. This approach likewise results in projections of varying uncertainty, all of which are presented in IPCC reports. The IPCC's prose reads rather wordy when those projections are enumerated, e.g., relative to the period 1850-1900 "… global temperatures averaged in the period 2081-2100 are projected to *likely* exceed 1.5 °C … for RCP4.5 [RCP stands for Representative Concentration Pathway, or scenarios explaining concentration and trajectories of aerosols and greenhouse and chemically active gases], RCP6.0 and RCP8.5 (*high confidence*) and … 2 °C … for RCP6.0 and RCP8.5 (*high confidence*). Temperature change above 2°C … under RCP2.6 is *unlikely* (*medium confidence*). Warming above 4 °C by 2081-2100 is *unlikely* in all RCPs (*high confidence*) except for RCP8.5, where it is *about as likely as not* (*medium confidence*)" (Chapter 12 in IPCC 2013a,

Stocker et al. 2013). In the former statement, *confidence* varies from *medium* to *high*, but *likelihood* only gets up to 66-100%, denoting the imperfect performance of those projections.

Lastly, we scientists can choose the interval of certainty of our measurements in our publications, and the IPCC authors are not different. Thus, when the Panel documents a given range of climate change, the '*likely* range' is the most common option. When assessed under different assumptions, models and scenarios, *likely* ranges are cited many times, hence magnifying the occurrence of climate findings at *likelihoods* of 66 to 100%. This magnification renders conservative many estimates of the most critical metrics of climate change reported in the in-depth chapters, namely cloud and aerosol forcing (Chapters 7 and 8), equilibrium climate sensitivity (Chapter 10), future global surface air temperatures, greenhouse-gas emissions, anthropogenic forcing and transient climate response (Chapters 11 and 12), and global sea level rise and its causes (Chapter 13) (IPCC 2013a). Additionally, *likely* ranges pass on from the in-depth chapters to the executive, policymaking-related and technical summaries, e.g., "… based on current understanding, only the collapse of marine-based sectors of the Antarctic ice sheet, if initiated, could cause global mean sea level to rise substantially above the *likely* range during the 21st Century" (IPCC 2013b).

Seepage: Organizations often labelled as climate-change 'contrarians', 'deniers' or 'sceptics' (see review of terms by Howarth and Sharman 2015) actively cherry-pick IPCC's calibrated statements as evidence to support their claims that the science backing anthropogenic climate change is flawed or biased towards alarmism or uncertain knowledge (table S3). Thus, calibrations have been in the spotlight of polemics such as 'Glaciergate', where the IPCC (Fourth Assessment Report) allocated a 90-100% *likelihood* (*very likely*) to a prediction of complete

meltdown of Himalayan glaciers by 2035, instead of three centuries into the future as intended

(Cogley et al. 2010). Once in the public sphere, calibrations can consequently undermine IPCC-

driven engagement of policy-making stakeholders, particularly if findings of weak uncertainty

predominate. The logical fallacy is that "… scientific uncertainty about climate science implies

uncertainty about whether something should be done in response to it" (Lewandowsky et al.

2015b). And such a fallacy becomes a flawed probabilistic device exploited by 'merchants of

doubts', who exploit uncertainty to discourage public endorsement of policies against a range of

societal problems, from smoking to global warming, usually with a clandestine financial ulterior

motive (Oreskes and Conway 2010).

The reality is that contrarian views against anthropogenic climate disruption can lobby

the scientific community, and the IPCC in particular, to be conservative and so reinforce

contrarian views in a vicious, self-reinforcing circle — a phenomenon called 'seepage'

(Lewandowsky et al. 2015b). Why? Essentially, the IPCC must carefully gauge the costs and

entailing loss of credibility of making a mistake given the heated and politicized debate about

climate change, so the Panel has a tacit motivation for using a cautious language. Medimorec and

Pennycook (2015) examined how the IPCC selects words and constructs sentences in its reports

relative to the Nongovernmental International Panel on Climate Change (NIPCC), a group of

'scientists' who define themselves as "… not predisposed to believe climate change is caused by

human greenhouse gas emissions' and … able to offer an independent *second opinion* of the

evidence reviewed — or not reviewed — by the IPCC on the issue of global warming"

(climatechangereconsidered.org). In actual fact, the NIPCC is staged by the Heartland Institute, a

conservative American "think tank" with a long history of attacks on climate science (e.g., they

once compared climate scientists to the Unabomber; Hickman 2012). Medimorec and Pennycook

(2015) found that the IPCC's language is far more cautious and less emotional than the NIPCC's, and the predominance of low to intermediate qualifiers found in our study aligns with the former observation.

Seepage seems perhaps the major motivation for the IPCC's WGI to 'err on the side of least drama' and so underestimate climate-change impacts (Brysse et al. 2013), and to overemphasize the avoidance of false-positive (supporting an untrue outcome) against false-negative (rejecting a true outcome) probabilistic statements (Anderegg et al. 2014). Even the coverage of new climate findings in the primary literature by the most-read US newspapers indicates that anthropogenic climate change can outpace the projections of the IPCC itself (Freudenburg and Muselli 2010). This is extraordinary because the US prestige press tends to balance their attention to arguments for humans *versus* natural variability as the main drivers of climate change, thereby creating the biased impression that both perspectives have equal backing in the scientific community (Boykoff and Boykoff 2004).

Challenges and future directions

Uncertainty is double-edged. Climate-change contrarians see uncertainty in IPCC reports as proof of weakness in climate science (table S3), ignoring the fact that uncertainty is inherent to scientific research. Most climate researchers, certainly those in the IPCC, see it instead as proof of scientific rigour. Regardless, uncertainty should be visualized as a sound measure of the risks imposed by climate change and inspire action rather than indifference (Lewandowsky et al. 2015a). We conclude this paper by highlighting potential improvements in the IPCC's calibrations and outreach.

Calibrations: We contend that a major communication caveat in IPCC assessments is that the Panel is not explicit about how a hierarchy of thousands of calibrated statements propagates their (often low to intermediate) uncertainties into the highly certain, core outcomes collectively supporting the fact that humans are (and, if not reducing emissions of greenhouse gases, will continue being) the main drivers of ongoing (and future) climate change. Additionally, it has been noted that in the IPCC's Assessment Reports "… many less-important conclusions have attached likelihoods, whereas some crucial ones do not", yet they are the most relevant ones to policymaking (Reilly et al. 2001). But current calibrations play no role in how and how much the latter causatively lead to the former. Thus, the WGI's 'Summary for Policymakers' (IPCC 2013b) and 'Headline Statements' (table 2; WGI Technical Support Unit 2014) use section-heading boxes (bolded text in colour-shaded frames) followed by a few synthesizing statements. However, only 10 of the 19 ('Summary for Policymakers') and none of the four ('Headline Statements'; table 2) boxes include calibrations, and the probabilistic link between headings and associated statements is open to (mis)interpretation.

In situations where climate-change contrarians misleadingly use IPCC reports as a house of cards (table S3), whereby the removal of one or few cards demolishes the whole or most of the house, both a graphical depiction and an explicit quantification of how core outcomes depend probabilistically on ancillary ones could help defang such attacks on the science of climate change. In the context of our study and for simplicity, we identify 'core outcomes' (table 2, see Cooke 2015) with the IPCC's 'Headline Statements' by WGI (table 2; Stocker and Plattner 2016, WGI Technical Support Unit 2014), along with the endorsements made by the US National Research Council (NRC 2010), while 'ancillary outcomes' are scientific findings leading to those core outcomes. However, if the IPCC was to address the probabilistic links between the

two explicitly, each of the IPCC's Working Groups should identify which are the core outcomes relative to the specific areas of climate science they revise (table S1) and the audiences they target (table 1).

Along those lines, the Fifth Assessment Report is typeset in italics to highlight *confidence* and *likelihood* exclusively for findings subject to uncertainty, not for "climate facts" (table 3), despite the latter being ostensibly scrutinized by the same review process as any other climate outcome. A useful analogy is that it is difficult to imagine that an employer would evaluate a set of job applicants' *curriculum vitae* by only taking the lowest-scoring subjects into consideration; instead, the employer would also rank their best subjects. Similarly, the omission of certainty qualifiers for factual outcomes seems inadvisable because they should represent gold standards of climate-change science, and therefore deserve a unique and highest category of certainty that no reader should be able to misinterpret easily. This seems a simple yet powerful way by which IPCC can provide a more balanced probabilistic treatment of outcomes of extreme certainty or uncertainty.

In general, most calibrated qualifiers currently used by the IPCC (Mastrandrea et al. 2011a: exceptionally, extremely, high, low, major, medium, minor, very, virtually), and the newly proposed ones (Mach et al. 2017: divergent, emerging, limited, robust) are unquantifiable, the amount of scientific evidence and agreement within and between *confidence* categories is unknown, and both aspects entertain subjective interpretation by readers of IPCC reports. We concur with others that a dual language coupling the numbers with the terms quantifying uncertainty thresholds (Budescu et al. 2014) would be an essential minimum for the IPCC's audiences (table 1) to interpret correctly what the IPCC is actually saying.

A different matter is whether the IPCC's calibration protocol might be underestimating the metrics of climate change, with experts noting that "*… if current scientific consensus is in error, it is likely because global climate disruption may be even worse than commonly expected to date*" (Freudenburg and Muselli 2013). For instance, by the end of the 21st Century, global warming rates have been claimed to be 15% higher and 30% less uncertain than the estimates given by the IPCC's WGI in the Fifth Assessment Report (Brown and Caldeira 2017). Likewise, lower bounds of the *likely* ranges of sea-level rise have been argued to be over 10 cm higher (Horton et al. 2014) than the IPCC estimates. Furthermore, Reilly et al. (2001) stressed that the method of attaining expert judgements is inconsistent through the IPCC Working Groups, and not detailed (e.g., to be replicable) in the IPCC calibration guidelines, and that the IPCC's emphasis on calibrating consensus might misrepresent the state of knowledge about climate change. This caveat has led many authors to advocate a move from informal (the current approach) to formal expert elicitation in IPCC assessments (e.g., Morgan and Mellon 2011, Oppenheimer et al. 2007, Zickfeld et al. 2010), whereby divergent expert views play a formal role in calibrations, and *likelihoods* could capture the uncertainty of not only model inputs (current approach), but also model structure (Morgan 2014, Reilly et al. 2001). It is of course unknown whether expert elicitation would change the overall frequency of qualifiers in IPCC reports that we have summarized in our study.

Outreach: The upswing in populist governments worldwide (Oliver and Rahn 2016) further threatens the public understanding of the IPCC's message and recommendations, so clarity of language is particularly important to counter public lack of awareness of anthropogenic climate change and the perception of its risks (Lee et al. 2015). Nevertheless, while climate-change

awareness is largely determined by educational attainment (Lee et al. 2015), risk perception can

respond to collective beliefs more than to science literacy or comprehension of scientific

information (Kahan et al. 2012). Thus, the improvement of the IPCC's probabilistic vocabulary

should not be treated as a panacea, but as one element of an unprecedented, global

communication strategy encompassing the sociological and psychological dimensions of the

potential audiences of IPCC reports (table 1). A clear wording of uncertainty will always rely on

a clear strategy of communication of words to transmit its genuine meaning. As an apolitical,

scientific, multidisciplinary, and authoritative body, the IPCC is the institutional beacon to

endorse such a strategy where scientific practice, policy making, and public engagement meet.

   The IPCC has greatly expanded, and foresees to expand further, its communication

capabilities, acknowledging that (*i*) "… effective outreach requires engagement with

stakeholders … to understand what they are looking for in an IPCC report", and (*ii*) "… involve

communications specialists from a range of disciplines in the writing process [of IPCC reports]"

(IPCC 2016b). In that direction, the IPCC has just issued a handbook for IPCC authors to

communicate uncertainty and promote public awareness of climate change (Corner et al. 2018).

However, we argue that instead of resorting to external, commissioned specialists and knowledge

brokers to generate communication tools for the IPCC Working Groups, the IPCC's credibility

and societal impact could be enhanced by launching a new IPCC's Working Group entirely

focused on climate-change outreach and based on the outputs of the three existing Working

Groups. This Outreach Working Group would ideally include communication experts from

different fields, comprising educators, linguists, pedagogues, psychologists, and climate

scientists (recruited from academia and non-academic sectors), and follow the same assessment

process as that of the remaining working groups (with 'contributing authors', 'expert reviewers',

and 'review editors'; see above). The group would elaborate a novel component in the IPCC's

assessments (i.e., a self-contained booklet, and one section in the overall synthesis report)

accounting for the heterogeneous, public perceptions of climate change (Weber 2010, 2016),

thus reaching beyond policymakers to other sectors like agriculture (e.g., farmers) or education

(e.g., school teachers).

To accomplish this complex task, it seems strategically important that each of the IPCC

member countries should define a network of relevant organizations linked across different

scales (local, regional, national) that maximize the flow of usable information (Kalafatis et al.

2015). Those networks might encounter both a common set of experiences that can be escalated

at the regional and national level (Buizer et al. 2016) and documented in IPCC reports, but also

context-specific situations needing innovative approaches (Clar and Steurer 2018) beyond the

direct scope of the IPCC. Representatives of those networks (at least at the regional level) could

participate as 'contributing authors' in the assessment process of the IPCC's Outreach Working

Group (in exactly the same way commissioned scientists contribute to the assessment by the

current three Working Groups) and subsequently, play the role of actors when outreach

recommendations were to be implemented nationally. In such a scheme, the IPCC would adopt a

leading role in managing the boundaries between knowledge (science) and action (policymakers

and stakeholders), which could enhance the credibility of climate information and the legitimacy

of emerging policies and applications (Cash et al. 2003).

Across the board, the scientific community (including the IPCC) would do well to

appreciate that once the cause of an environmental problem has been unambiguously identified

(e.g., that humans are changing the Earth's climate), doing more research, producing more

papers or assembling larger reports, solely to reduce the amounts of uncertainty or to strengthen

the message, is potentially ineffective in the public domain because uncertainty (Oreskes 2015, Sarewitz 2004) and much of the scientific jargon (Kueffer and Larson 2014, Weber and Schell-Word 2001) have different meanings and implications in the sciences relative to society and politics. Those realms speak different languages. Knowledge that scientists might identify as 'useful' for policymakers could in fact be labelled by policymakers as not 'usable' for taking actions (Lemos et al. 2012). After all, the resolution of environmental problems is always in the political court no matter how widespread and consolidated scientific consensus might be. In the scientific court, one of the most urgent actions we scientists can currently take to address the climate crisis is to communicate unequivocally to non-scientists the state of knowledge. We should frame and underline what the data tell us that we know for certain about climate change, and be transparent about those areas that remain uncertain and by how much.

Acknowledgements

Author contributions

SH-P conceived the idea, collated calibrations and wrote first draft. All authors contributed to revisions.

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24

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Biographical narrative

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Table 1. Intergovernmental Panel on Climate Change's (IPCC) target audiences literally quoted from its communication strategy (IPCC 2016a).

The primary target audiences of the communications efforts of the IPCC are governments and policy-makers at all levels, the UNFCCC[1], and the UN-wide system intergovernmental processes more broadly
Broader audiences, such as IPCC observer organizations, the scientific community, the education sector, non-governmental organizations, the business sector and the wider public also have an interest in the work and assessments of the IPCC. While these are not the primary audiences of the IPCC communications efforts, the IPCC should look for ways to ensure that information is available and accessible for these audiences.
Third parties can play an additional valuable role taking elements of IPCC assessments to create accessible products aimed at specific audiences. The IPCC takes note of such derivative products, and may engage with relevant organizations that produce them. However, such products must not be considered joint productions or in any way products of the IPCC.
Engaging and building relationships with the media is an important way in which the IPCC can communicate the information contained in its reports, as well as its processes and procedures.
IPCC audiences are truly global in extent and are therefore very diverse. In its communications and outreach activities, the IPCC will take the specific context of different countries into account, which may require tailor-made outreach activities. For instance, communications needs of developing countries may be different to those of developed countries

[1] *UNFCCC = United Nations Framework Convention on Climate Change / UN = United Nations*

Table 2. Two sets of core conclusions by the Intergovernmental Panel on Climate Change (IPCC) and the US National Research Council (NRC). The first set shows (left column) literal overarching statements about the 'Physical Science Basis' of climate change in the IPCC's Fifth Assessment Report as stated in the 'Headline Statements' (WGI Technical Support Unit 2014), and (right column) the number of climate outcomes (n) that are attributed to a given confidence *and* likelihood *through those statements. The second set shows the endorsements by the NRC (2010) based on the IPCC's outcomes of* high *and* very high confidence *after Cooke (2015).*

IPCC statements	Mean rank[1,2] ± SE
Observed Changes in the Climate System: Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased.	*Confidence* = 3.8 ± 0.3 (*n* = 4) *Likelihood* = 4.0 ± 1.0 (*n* = 3)
Drivers of Climate Change: Total radiative forcing is positive, and has led to an uptake of energy by the climate system. The largest contribution to total radiative forcing is caused by the increase in the atmospheric concentration of CO_2 since 1750.	*Confidence* (*n* = 0) *Likelihood* (*n* = 0)
Understanding the Climate System and its Recent Changes: Human influence on the climate system is clear. This is evident from the increasing greenhouse gas concentrations in the atmosphere, positive radiative forcing, observed warming, and understanding of the climate system.	*Confidence* = 5 (*n* = 1) *Likelihood* = 5 (*n* = 1)
Future Global and Regional Climate Change: Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.	*Confidence* = 4 (*n* = 1) *Likelihood* = 3.0 ± 0.5 (*n* = 5)
NRC endorsements	

i/ Earth is warming

ii/ Most of the warming over the last several decades can be attributed to human activities.

iii/ Natural climate variability cannot explain or offset the long-term warming trend.

iv/ Global warming is closely associated with a broad spectrum of other changes.

v/ Human-induced climate change and its impacts will continue for many decades.

vi/ The ultimate magnitude of climate change and the severity of its impacts depend strongly on the actions that human societies take to respond to these risks.

[1] *Confidence* **ranks:** *very low* =1, *low* = 2, *medium* = 3, *high* = 4, *very high* = 5.

[2] *Likelihood* **ranks:** *about as likely as not* = 1, *more likely than not* = 2, *likely* or *unlikely* = 3, *very likely* or *very unlikely* = 4, *extremely likely* or *extremely unlikely* = 5, *virtually certain* or *exceptionally unlikely* = 6. See figure 1 and footnote of figure 2.

Table 3. Literal recommendations in the Intergovernmental Panel on Climate Change's guidance note for lead authors of the Fifth Assessment Report (Mastrandrea et al. 2011a) that enhance the frequency of weak-certainty statements.

- Because risk is a function of probability and consequence, information on the tails of the distribution of the outcomes can be specifically important. Low-probability outcomes can have significant impacts, particularly when characterized by large magnitude, long persistence, broad prevalence, and/or irreversibility. Author teams are therefore encouraged to provide information on the tails of distributions of key variables, reporting quantitative estimates when possible and supplying qualitative assessments and evaluations when appropriate.

- For findings (effects) that are conditional on other findings (causes), consider independently evaluating the degrees of certainty in both causes and effects, with the understanding that the degree of certainty in the causes may be low.

- The [*likelihood*] categories can be considered to have "fuzzy boundaries". A statement that an outcome is "likely" means that the probability of an outcome can range from ≥66% (fuzzy boundaries implied) to 100% probability… When there is sufficient information, it is preferable to specify the full probability distribution or a probability range (e.g., 90-95%) without using the [*likelihood*] terms.

- Consider that, in some cases, it may be appropriate to describe findings for which evidence and understanding are overwhelming as statements of fact without using uncertainty qualifiers.

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FIGURE CAPTIONS

Figure 1. Procedures for assigning **confidence** *and* **likelihood** *qualifiers to the scientific evidence for anthropogenic climate change in the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report, and as proposed by the Core Writing Team for future assessments — modified from Mach et al. (2017). Numbered circles represent steps in the assessment process.*

Figure 2. Proportion of **confidence** *(top row) and* **likelihood** *(bottom row) qualifiers in the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report (Working Group I: The Physical Science Basis). Counts cover the 'Summary for Policymakers' (a, b), the 'Technical Summary' (c, d), and the executive summaries (e, f) and main text (g, h) of the in-depth chapters. Histograms show decreasing uncertainty from lower to upper categories. Horizontal lines in grey are mean ranked[1] uncertainties ± two standard errors (sample sizes reported in supplemental table S1).*

Footnote (figure 2)

[1] *Confidence* **ranks:** *very low* =1, *low* = 2, *medium* = 3, *high* = 4, *very high* = 5. *Likelihood* **ranks:** *about as likely as not* = 1 (33-66 %), *more likely than not* = 2 (>50 %), *likely* (> 33 %) or *unlikely* (< 66 %) = 3, *very likely* (> 90 %) or *very unlikely* (< 10 %) = 4, *extremely likely* (> 95 %) or *extremely unlikely* (< 5 %) = 5, *virtually certain* (> 99 %) or *exceptionally unlikely* (< 1 %) = 6

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SUPPLEMENTAL MATERIAL

METHODS AND EXPANDED RESULTS

Statistical Language Backs Conservativeness
in Climate-Change Assessments

Salvador Herrando-Pérez

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Stephan Lewandowsky

David R. Vieites

Hereafter, hyperlinks in blue re-direct to the Intergovernmental Panel on Climate Change's (IPCC) website for full access of contents from the Fifth Assessment Report. Calibration guidelines for IPCC lead authors can be downloaded from www.ipcc.ch/pdf/supporting-material/uncertainty-guidance-note.pdf.

Study documents and calibrations

We focused on one component of the IPPC's Fifth Assessment Report, namely 'The Physical Science Basis' (Working Group I: IPCC 2013a) because it deals with the scientific evidence for anthropogenic climate change for which there is robust support in the scientific community (Benestad et al. 2016, Cook et al. 2013, Cook et al. 2016, Oreskes 2004). Therefore, we counted the number of calibrated qualifiers of *confidence* and *likelihood* in the 'The Physical Science Basis'. *Confidence* and *likelihood* qualifiers therein can be easily tracked because they are italicized. For *likelihoods*, we pooled statements of identical probability, that is, *likely* & *unlikely*, *very likely* & *very unlikely*, *extremely likely* & *extremely unlikely*, and *virtually certain* & *exceptionally unlikely*, because the two elements of each of those duets represent the same

magnitude of uncertainty for a positive and negative statement, respectively (figure 1). We estimated mean ranked calibrations by transforming qualifiers to ranks for both *confidence* (ranks: *very low* =1, *low* = 2, *medium* = 3, *high* = 4, *very high* = 5) and *likelihood* (ranks: *about as likely as not* = 1, *more likely than not* = 2, *likely* or *unlikely* = 3, *very likely* or *very unlikely* = 4, *extremely likely* or *extremely unlikely* = 5, *virtually certain* or *exceptionally unlikely* = 6). So, qualifier duets and ranks are as follows:

Rank	*Likelihood*	*Confidence*
6	*virtually certain (99-100 %)* or *exceptionally unlikely (0-1%)*	
5	*extremely likely (95-100 %)* or *extremely unlikely (0-5%)*	*very high*
4	*very likely (90-100 %)* or *very unlikely (0-10%)*	*high*
3	*likely (66-100 %)* or *unlikely (0-33%)*	*medium*
2	more likely than not *(50-100 %)*	*low*
1	about as likely as not *(33-66 %)*	*very low*

The Physical Science Basis

This Fifth Assessment Report component consists of 'Foreword, Preface and Dedication', 'Summary for Policymakers', 'Technical Summary', 14 in-depth chapters, 'Headline Statements', and complementing information including frequently asked questions, glossaries, content translation from English into other languages, and a slide presentation (table S1). The 14 in-depth chapters are (Chapter number / Title / First page):

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Chapter 1 Introduction. 119
Chapter 2 Observations: Atmosphere and Surface. 159
Chapter 3 Observations: Ocean. 255
Chapter 4 Observations: Cryosphere. 317
Chapter 5 Information from Paleoclimate Archives. 383
Chapter 6 Carbon and Other Biogeochemical Cycles. 465
Chapter 7 Clouds and Aerosols. 571
Chapter 8 Anthropogenic and Natural Radiative Forcing. 659
Chapter 9 Evaluation of Climate Models. 741
Chapter 10 Detection and Attribution of Climate Change: from Global to
Regional. 867
Chapter 11 Near-term Climate Change: Projections and Predictability. 953
Chapter 12 Long-term Climate Change: Projections, Commitments and
Irreversibility . 1029
Chapter 13 Sea Level Change. 1137
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Frequency of calibrations

We counted the frequency of calibrated qualifiers in two batches: (*i*) from the printed booklets of the 'Summary for Policymakers' (IPCC 2013b) and the 'Technical Summary' (Stocker et al. 2013) directly posted to lead author SHP by the IPCC's headquaters in Geneva (Switzerland); and (*ii*) from the digital version (using the 'Find' command in Acrobat Reader©) of in-depth Chapters 2 to 14 including climate assessments (IPCC 2013a) and available from the IPCC's website (www.ipcc.ch/report/ar5/wg1). We excluded Chapter 1 from the counts because it is an introduction to concepts, definitions, climate-change indicators (and how they compare to the Fourth Assessment Report), scenarios and the state of the art of climate science as used in the remaining chapters. Throughout, we eliminated *confidence* calibrations that were not assigned to categories from *very low* to *very high*, for which only 'strength of evidence' *and* 'agreement' had been provided (see figure 1).

We refer to boxes, figures, and tables complementing the main text of any given component of the IPCC's 'The Physical Science Basis" collectively as 'displays'. Displays in Chapter 14 ('Climate Phenomena and their Relevance for Future Regional Climate Change'; see above) accounted for 28 % ($n = 454$) of the total number of qualifiers found in all of the in-depth chapters ($n = 1604$), while displays in Chapters 2 to 13 altogether only accounted for 12 % ($n = 195$) of the total. To avoid biasing our analyses of calibrations by climate findings about future regional climate change, we present in figure 1 the frequency of calibrations of the main text of all in-depth chapters, and in figure S1 the frequency of calibrations of the displays distinguishing Chapter 14 from the remaining chapters. The executive summaries of individual in-depth chapters lack displays, so this caveat did not affect those summaries. On the other hand, in the 'Summary for Policymakers' and the 'Technical Summary', calibrations of the same statements were reported sometimes in the main text *and* in some displays, so we only counted once the calibrated qualifiers of those statements (79 in total). This caveat did not affect the 'Headline Statements' (no displays therein), nor the in-depth chapters because, as stated above, we reported the frequency of calibrated qualifiers separately for the main text and displays.

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Data

We have stored statements including calibrated qualifiers from the 'Summary for Policymakers'
and the 'Technical Summary' in an Excel file, while we have highlighted qualifiers in the in-
depth chapters in yellow in a copy of the full report by the IPCC's Working Group I. Both the
Excel file and the highlighted report are available upon request from the lead author
(salherra@gmail.com / salvador.herrando-perez@adelaide.edu.au).

4

Table S1. Structure of the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report.

Publication	Content
Synthesis Report (IPCC 2014d; 151 p)	• Foreword, Preface, Dedication • Summary for Policymakers • Introduction + Topics 1 to 4 • Annexes (I to VI) • Index and Errata • Full report in Arabic, Chinese, English, French, German, Korean, Russian and Spanish • Summary for Policymakers in Arabic, Catalan, Chinese, English, French, German, Hungarian, Korean, Russian, Spanish • Headline statements from the Summary for Policymakers in Arabic, Chinese, English, French, Russian, Spanish • Drafts and review materials • Slide presentation
Working Group I *The Physical Science Basis* (IPCC 2013a; 1535 p)	• Foreword, Preface, Dedication • Summary for Policy makers • Technical Summary • Chapters 1 (Introduction) to 14 • Annexes I to VI • Index and Errata • Summary for Policymakers, Technical Summary and FAQ in Arabic, Chinese, English, French, Russian and Spanish • Summary for Policymakers in Czech, Dutch, German, Italian, Japanese, Korean, Polish and Slovenian • Headline statements from the Summary for Policymakers in Arabic, Chinese, English, French, Russian, Spanish • Drafts and review materials • Slide presentation
Working Group II *Impacts, Adaptation, and Vulnerability* (IPCC 2014a, b; 1820 p)	• Part A: Global and Sectoral Aspects 　Foreword, Preface, Dedication 　Summary for Policymakers 　Technical Summary 　Cross-chapter Boxes (15 in total) 　Chapters1 to 20 • Part B: Regional Aspects 　Chapters 21 to 30 　Annexes I to IV 　Index and Errata • Summary for Policymakers, Technical Summary, FAQ and cross-chapter boxes in Arabic, Chinese, English, French, Russian and Spanish • Summary for policymakers in Czech, German, Japanese, Korean, Portuguese, Swedish • Top level findings from the Summary for Policymakers in Arabic, Chinese, English, French, Russian and Spanish • Drafts and review materials • Slide presentation
Working Group III	• Foreword, Preface, Dedication, *In Memoriam* • Summary for Policymakers • Technical Summary • Introductory Chapter, Chapters 1 to 16

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| *Mitigation of Climate Change* (IPCC 2014c; 1435 p) | Annexes I to VI Index and Errata Summary for Policymakers, Technical Summary and FAQ in Arabic, Chinese, English, French, Russian, Spanish Summary for Policymakers in German Drafts and review materials Slide presentation |

Table S2. Mean ± standard error and median [90% interquartile ranges] of **confidence** *and* **likelihood** *(2nd and 3rd columns) in statements from the main text (upper data row) and displays* (lower data row) different components (1st column) of Working Group I's 'The Physical Sciences Basis' in the Fifth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC). Means and medians obtained after ranking qualifiers from lowest = 1 to highest = 5 (*confidence[1]*) or 6 (*likelihood[2]*) strength of evidence. nC = number of* **confidence** *qualifiers, nL = number of* **likelihood** *qualifiers.*

'The Physical Science Basis"	*Confidence*	*Likelihood*
Summary for Policymakers	**3.3** ± 0.1	**3.5** ± 0.2
(*nC* = 136, *nL* = 120)	**3** [2,5]	**3** [3,6]
Technical Summary	**3.2** ± 0.1	**3.5** ± 0.1
(*nC* = 322, *nL* = 245)	**3** [2,5]	**3** [3,6]
Executive summaries (in-depth chapters)	**3.2** ± 0.1	**3.5** ± 0.1
(*nC* = 269, *nL* = 223)	**3** [2,5]	**3** [3,6]
Main text (in-depth chapters)	**3.1** ± 0.1	**3.5** ± 0.1
(*nC* = 603, *nL* = 533)	**3** [2,4]	**3** [3,5]
Displays[3] (in-depth chapters)	**3.3** ± 0.1	**3.5** ± 0.2
(*nC* = 649, *nL* = 91)	**3** [2,4]	**3** [3,5]

[1] **Confidence ranks:** very low =1, low = 2, medium = 3, high = 4, very high = 5.

[2] **Likelihood ranks:** about as likely as not = 1 (33-66 %), more likely than not = 2 (> 50 %), likely (> 66 %) or unlikely = 3 (< 33 %), very likely (> 90 %) or very unlikely (< 10 %) = 4, extremely likely (> 95 %) or extremely unlikely (< 5 %) = 5, virtually certain (> 99 %) or exceptionally unlikely (< 1 %) = 6.

[3] **Displays** = boxes, figures and tables

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Table S3. Sample of critiques to the Intergovernmental Panel on Climate Change's (IPCC) calibrated statements by contrarians to, or deniers or sceptics of, the science supporting anthropogenic climate change. Both statements and critiques are literal quotations.

IPCC statement	Critique of calibration	Reference
Direct comparisons between assessment of uncertainties in findings in this report and those in the IPCC Fourth Assessment Report … are difficult, because of the application of the revised guidance note on uncertainties [i.e., calibrations], as well as the availability of new information	We learn that one cannot really compare the confidence/certainty assessments of AR5 [Fifth Assessment Report] with previous reports, so it's not safe to say that things have "grown more certain" despite what various news and interest-group reports claim. As one can see, the reality of the IPCC's certainty is that it's really just a best guess, a self-assessment by authors with a vested interest in having their work believed by policymakers	American Enterprise (Green 201
It is *very likely* that anthropogenic greenhouse gas increases caused most of the observed increase in [globally-averaged land and sea surface absolute temperature]	Here as elsewhere the IPCC assigns a 90% confidence interval to "very likely", rather than the customary 95% (two standard deviations). There is no good statistical basis for any such quantification, for the object to which it is applied is, in the formal sense, chaotic	American Society (Monckton
Most of the observed warming over the last 50 years is *likely* to have been due to the increase in greenhouse gas concentrations … natural forcing alone [solar and/or volcanic activity] is *unlikely* to explain the increased rate of global warming since the middle of the 20th century	The promiscuous use of such vague terms as "likely" and "unlikely" by scientists who are trained in precision speaks volumes about how much is unknown. At the very least, such language makes it impossible to accept the Greens' claim that "the debate is over", particularly given all the uncertainty – fully discussed in the IPCC report – regarding long-term climate records and important data on atmospheric feedbacks	CATO Inst (Taylor 200
A footnote in the new report [draft of the 5th Assessment Report] explains how their ideas have been applied: If the report says something is "virtually certain," it means there's a 99 percent chance that it's true. "Very likely" refers to any probability between 90 percent and 99 percent, "more likely than not" refers to a chance greater than 50 percent, and "unlikely" is somewhere between 10 percent and 33 percent.	The uncertainty cops argue that in the face of global warming—and the spin campaign to discredit it—we must do whatever it takes to boost the credibility of the experts. If the public is more inclined to believe in percentages, then the experts should give them percentages. It's a reasonable argument and one that could help us to address the precipitous rise in greenhouse-gas emissions. But we have to acknowledge that the new headline-grabbing rhetoric of climate change has elements of propaganda. However valid its conclusions, the report toys with our intuitions about science—that a number is more precise than a word, that a statistic is more accurate than a belief.	Engber (20
It is *extremely likely* that human influence has been the dominant cause of the observed warming since the mid-20th century	[This statement] is only a restatement of the opinions of activists and advocates in the field of global warming, and not a statement about the underlying science, which remains incomplete and uncertain. This is the same flawed reasoning and semantic games as used by the IPCC to make the same statement. It is not a statement of scientific fact, but rather of "some experts' opinions" without any basis in probability analysis or scientific forecasting	Heartland I (Bast 2017)
[*Low confidence*] … that damaging increases will occur in either drought or tropical cyclone activity	By admitting it has "low confidence" in predictions of more frequent or more extreme droughts and tropical cyclones, IPCC is specifically revoking its previous more alarmist claims	NIPCC (Idso et al.
According to the "IPCC Guidance Notes", their "Quantitatively calibrated levels of confidence" means for "Medium confidence" "about 5 out of 10 chance".	There is hence a "medium confidence" of getting heads or tails by flipping a coin, or an answer like "yes" or "no" to a question. I would call this pure chance instead of medium confidence. In statistics we were taught to make numerical estimates based on probabilities of a large population, in order to be allowed to use statistical expressions. Not like IPCC using statistical expressions based on subjective expert judgments! In this way IPCC is making a false impression that serious numerical statistical estimates have been made, while they have not.	Segalstad (
It is *extremely likely* that more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused by the anthropogenic increase in greenhouse gas concentrations and other anthropogenic forcings together	There is no established probability distribution presented. Thus, the term "extremely likely" is more based on the opinion of the political actors writing the SPM [Summary for Policymakers], than on any objective probability distribution	The Scienc Environme Policy Proj (Haapala 2

[1] *With regard to this publication, the author stated '…For what it's worth, I know longer hold these opinions' (Jerry Taylor, pers. comm., 02/04/2018)*

Figure S1. Proportion of **confidence** *(top row) and* **likelihood** *(bottom row) qualifiers in the in-depth Chapters[1] 2 to 14 of the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report (Working Group I: The Physical Science Basis). Counts cover the executive summaries[2] (a, b; one per chapter), the main text[2] (c, d), and displays[3] of Chapters 2 to 13 (e, f) and Chapter 14 (g, h). Histograms show decreasing uncertainty from lower to upper categories. Horizontal lines in grey are mean ranked[4] uncertainties ± two standard errors (sample sizes reported in footnote [5]).*


[1] Chapter 1 is an introduction to concepts, definitions, climate-change indicators (and how they compare to the Fourth Assessment Report), scenarios and the state of the art of climate science as used in the remaining chapters.

[2] Panels a, b, c and d in figure S1 are the same as panels e, f, g, h in figure 1, respectively.

[3] Displays = boxes, figures and tables

[4] *Confidence* ranks: *very low* =1, *low* = 2, *medium* = 3, *high* = 4, *very high* = 5. *Likelihood* ranks: *about as likely as not* = 1 (33-66 %), *more likely than not* = 2 (> 50 %), *likely* (> 66 %) or *unlikely* = 3 (< 33 %), *very likely* (> 90 %) or *very unlikely* (< 10 %) = 4, *extremely likely* (> 95 %) or *extremely unlikely* (< 5 %) = 5, *virtually certain* (> 99 %) or *exceptionally unlikely* (< 1 %) = 6.

[5] Samples sizes (*NC* = number of *confidence* qualifiers, *NL* = number of *likelihood* qualifiers): executive summaries (*NC* = 269, *NL* = 223), main text (*NC* = 603, *NL* = 533), chapters 2 to 13 (*NC* = 195, *NL* = 84), and chapter 14 (*NC* = 345, *NL* = 7). Reported *likelihoods* in chapter 14 were seven times only *likely* (90-100%) so the standard error across different calibrations is 0.
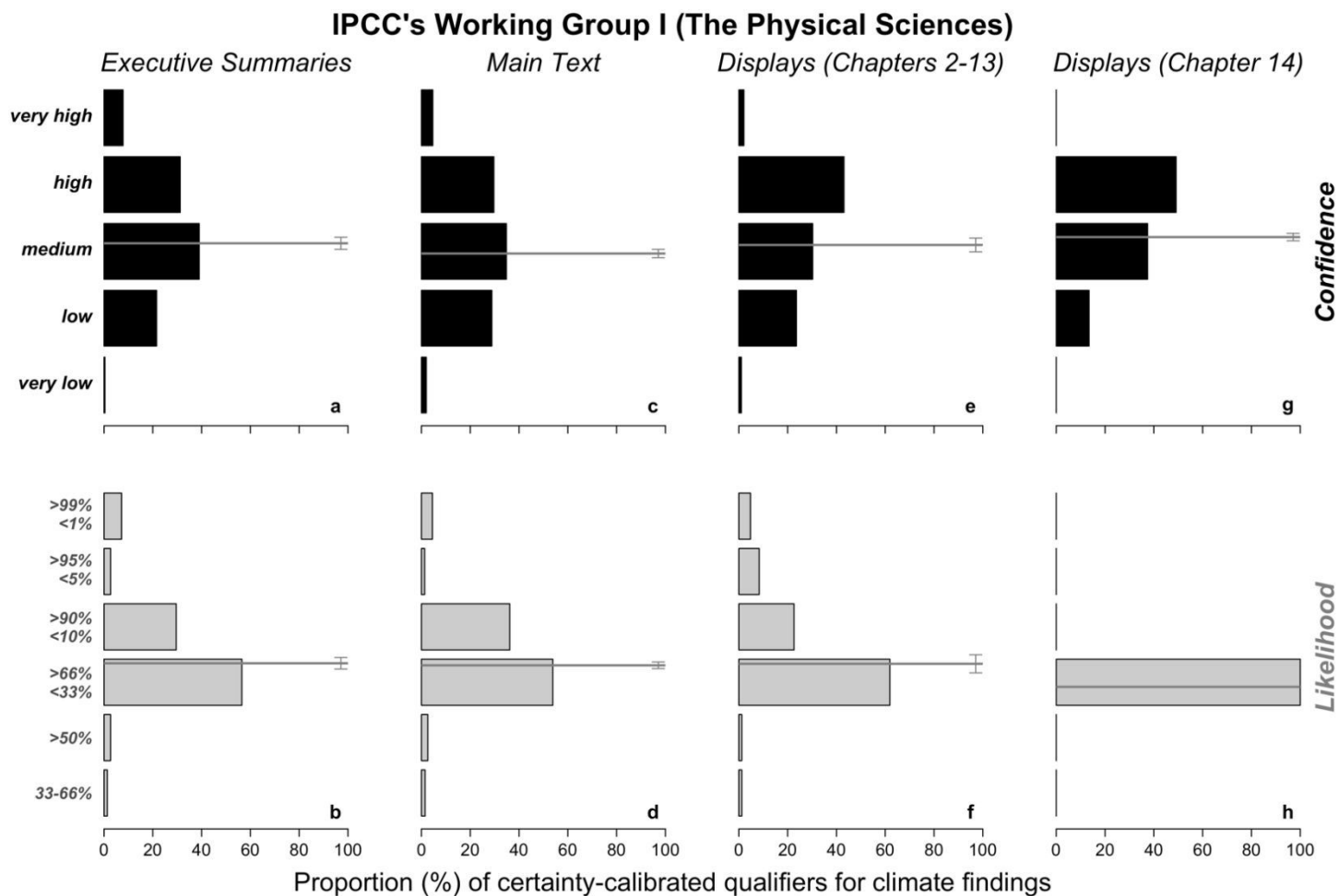
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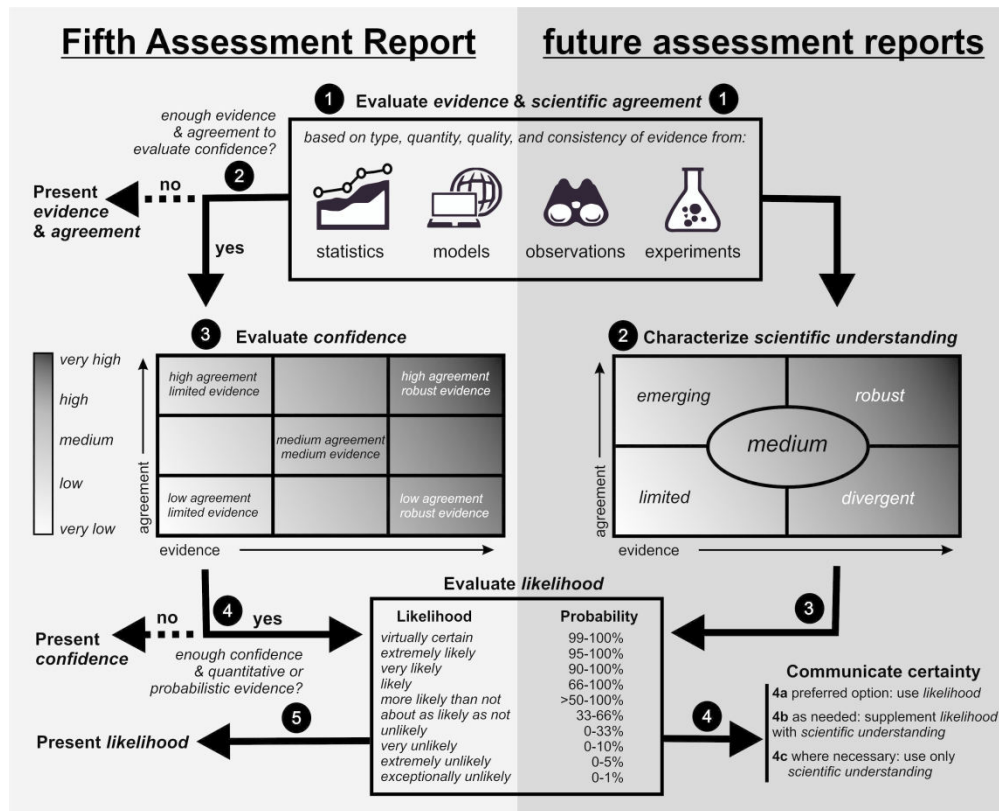Change. Cambridge, UK: Intergovernmental Panel on Climate Change.

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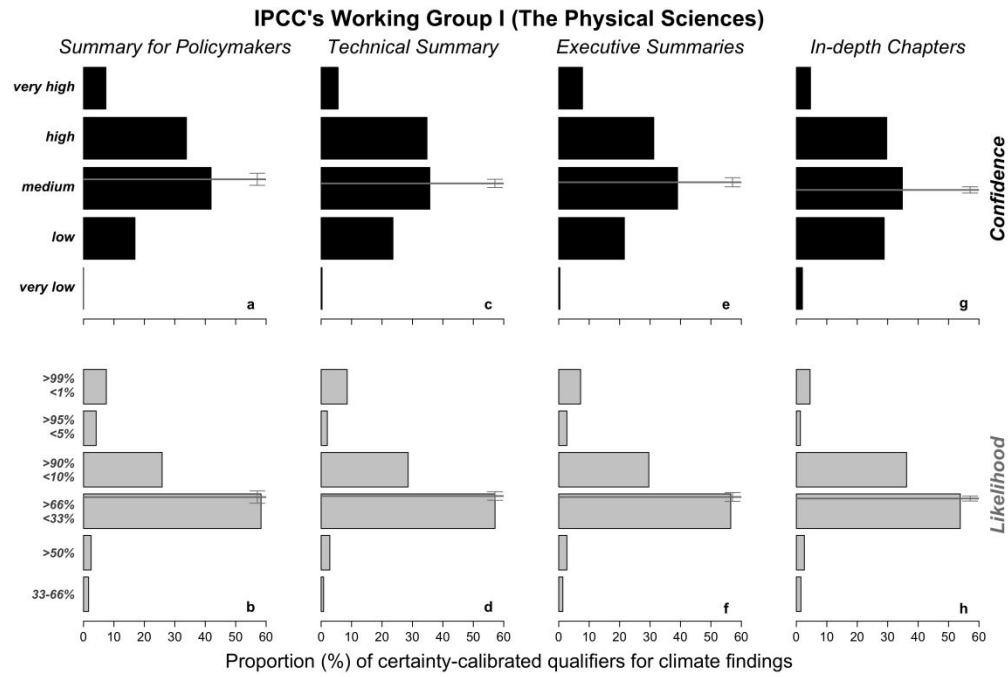Cambridge-UK & New York-US: Cambridge University Press.

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